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The Translation of Teachers' Understanding of Gifted Students Into Instructional Strategies for Teaching Science

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Abstract This study examined how instructional challenges presented by gifted students shaped teachers' instructional strategies. This study is a qualitative research grounded in a social constructivist framework. The participants were three high school science teachers who were teaching identified gifted students in both heterogeneously- and homogeneously-grouped classrooms. Major data sources are classroom observations and interviews. Data analysis indicated that these science teachers developed content-specific teaching strategies based on their understanding of gifted students, including: (a) instructional differentiation, e.g., thematic units, (b) variety in instructional mode and/or students' products, (c) student grouping strategies and peer tutoring, (d) individualized support, (e) strategies to manage challenging questions, (f) strategies to deal with the perfectionism, and (g) psychologically safe classroom environments.

Keywords Gifted education in science · Knowledge for teaching · Knowledge of students · Instructional · Strategies · Instructional challenges

Introduction

Recent reports providing direction to the reform of STEM education (e.g., Augustine 2006; National Science Board 2007) as well as many other research

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studies (e.g., Calderhead 1996; Doyle and Ponder 1977; Sanders 2000) have stressed the importance of having high quality science teachers in the classroom. The Institute for Educational Leadership (2001) declared that "student learning depends first, last, and always on the quality of teachers" (p. 1). The value of teachers in education appears to be especially salient in nurturing gifted students. Croft (2003) noted that gifted students are more profoundly impacted by their teachers' attitudes and actions than are other students, because they have unique needs and interests. Renzulli (1968) asserted that teachers are critical to the success of gifted programs, since they have a significant influence on a learning environment to meet gifted students' special needs. Sisk (1989) also highlighted the importance of teachers in educating gifted students stating that considerable data support that nothing matters in the school more than the teacher.

Gifted students, as a group, have different cognitive, affective, physical, intuitive, and societal characteristics compared to their age mates (Karnes and Bean 2001). Because of this, gifted students bring unique educational needs into science classrooms. Contrary to the common belief that gifted students will make it on their own, research suggests that these students cannot succeed without specialized assistance (Colangelo and Davis 1997). Therefore, teachers of gifted students need to implement specially adapted pedagogical procedures for teaching a subject in order for their gifted students to reach their potential. To this end, in order to meet gifted students' special learning needs, the teachers need ongoing professional development related to their knowledge for teaching as well as ongoing reflection on their practice. With this in mind, this study investigated how gifted students' characteristics and subsequent special instructional challenges function in developing their teachers' instructional strategies and knowledge for teaching. The research questions that guided this study were as follows.

1. What are the instructional challenges gifted students bring to both homogeneously- and heterogeneously-grouped science classrooms?
2. How do those instructional challenges influence the teachers' instructional strategies?

The purpose of this study was twofold. From a theoretical point of view, this study aimed to gain a more sophisticated understanding of how gifted students' unique characteristics influence the means through which teachers' instructional strategies are developed, revamped, and validated regardless of whether the gifted students are in homogeneously- or heterogeneously-grouped science classes. This understanding will provide insights into the ways that teachers translate their awareness of individual students' learning needs into curricular events. The other purpose was drawn from a practical point of view. Much research has proposed that teacher knowledge for teaching can be improved when teachers develop a better understanding of their students (e.g., Clermont et al. 1994; Lederman et al. 1994; Loughran et al. 2000). There is a strong likelihood that understanding of individual students is a critical source for improving teacher knowledge and subsequent teaching practices (Barnett and Hodson 2000; De Jong et al. 2005). However, insufficient attention has been paid to the role that students play in shaping their teachers' teaching practices. In this regard, through explication of "the practical

pedagogical wisdom" (Shulman 1987) of experienced science teachers of gifted students, this study meant to provide useful guidelines for prospective and experienced teachers to "develop their repertoire of responses, understandings, and magical tricks" (Grimmett and MacKinnon 1992, p. 441) for teaching gifted students. Moreover, teaching strategies identified from this study could become goals, objectives, or outcomes of teacher education programs for working with gifted students in science education.

Theoretical Background

Social Constructivism

We employed social constructivism as a theoretical framework for this study, and as such that framework shapes "the meaning of research questions, the purposiveness of research methodologies, and the interpretability of research findings" (Crotty 1998, p. 17). From the social constructivist view, knowledge is not discovered, but constructed within individual minds through social interactions. Our knowledge construction involves agreement and interaction with other individuals and in this regard it is the act of becoming socialized into the practices of the community in which we are embedded (Wertsch and Toma 1995). In a nutshell, knowledge is socially constructed, communicated, and validated.

In this vein, teachers develop their knowledge for teaching through social interaction, negotiation, and co-construction of meaning within social contexts where they are situated (Barnett and Hodson 2000). Consequently, teachers' knowledge for teaching is intimately related to the specific social situations, interaction, and communities, through which that knowledge has been generated, validated, maintained, and used. In this regard, social interaction with others such as students, colleagues, administrators, and parents is a major factor in the construction and reconstruction of knowledge for teaching (Bell 1998).

This social constructivist perspective on knowledge construction provided significant guidance to this study in two major ways. First, we strove to fully take into consideration the real teaching settings in which the participants were working when we investigated their understanding of gifted students and teaching practices. To this end, we documented the research context as richly and thickly as possible in the course of the study including the creation of detailed field notes. Second, a teacher's knowledge for teaching is deeply rooted in teaching contexts where the interactions between the teacher and students occur. In this regard, we placed a great emphasis on verbal and nonverbal interaction between the teacher and gifted students and among students (i.e., between gifted and gifted/non-gifted students) during classroom observations. In particular, our attention was directed to teachers' interactions with gifted students based in three sources of evidence related to our research questions: (1) connections made between a teacher's instructional plan and the teacher's understanding of gifted students, (2) teaching strategies implemented for which there were initial or subsequent evidence of grounding in the teacher's

understanding of gifted students, and (3) responses to and interchange with gifted students while teaching.

Knowledge for Teaching Gifted Students

Researchers in gifted education and teacher education have devoted increased attention to the question: From what knowledge bases should teachers draw in order to help gifted students reach their potential? (e.g., Baldwin 1993; Baldwin et al. 2000; Feldhusen 1997). As a result of a literature review, three teacher knowledge bases appear especially critical to educating gifted students: (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) knowledge of gifted students.

Subject matter content knowledge. A number of researchers have suggested that successful teachers of gifted students possess sophisticated knowledge of the subject matter they are teaching (Clark 1997; Feldhusen 1997; Gallagher 2000; Parker 1996; VanTassel-Baska 1998). Teachers with advanced understandings of their subject areas are flexible enough to ask higher-level questions, better engage students, and enable students to apply and transfer knowledge (Rigden 2000). VanTassel-Baska (1998) pointed out that academic growth gains and motivation of the gifted students were greater in those science classrooms where the teacher grasped the structure of the discipline being taught and could reiterate it in powerful ways throughout the units. Thus we concluded that teachers of gifted students should be comfortable and flexible with the subject matter they are teaching as a precondition for meeting the instructional challenges that accompany gifted students' special needs.

Pedagogical content knowledge. While some scholars emphasize the importance of subject matter content knowledge in teaching the gifted, there is significant evidence that subject matter knowledge alone is insufficient to support student learning (see Schneps 1988). In a study of middle school teachers, Hollon et al. (1991) found that, despite their superior subject matter knowledge, some teachers were not able to effectively use that knowledge to help their students develop scientific knowledge. Darling-Hammond (2000) mentioned that "although knowledge of the material to be taught is essential to good teaching, subject matter knowledge is a positive influence up to some level of basic competence but is less important thereafter" (p. 4). Shulman (1986) asserted that "mere content knowledge is likely to be as useless pedagogically as content-free skill" (p. 8). Therefore, teachers should develop knowledge that is more than subject matter knowledge; this knowledge should bridge between the traditional areas of subject matter and pedagogy to produce an amalgamated knowledge base for teaching.

In this vein, Shulman (1986) coined the concept of pedagogical content knowledge (PCK) as a distinctive body of knowledge for teaching in order to acknowledge the importance of the transformation of subject matter knowledge per se into subject matter knowledge for teaching. PCK "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse

interests and abilities of learners, and presented for instruction" (Shulman 1987, p. 8). In essence, PCK refers to particular topics and concerns the teaching of the particular topics (Van Driel et al. 1998). Because of this nature of PCK, many researchers have suggested that subject matter content knowledge is one of major sources that promote PCK development (Grossman 1990; Shulman 1987; Grossman et al. 1989). Along with this line, it is accepted that adequate subject matter knowledge is a prerequisite for PCK (Van Driel et al. 1998). Taken together, teachers for gifted students should possess developed PCK based on sufficient subject matter content knowledge.

Knowledge of gifted students. In keeping with Shulman's (1987) definition of PCK, we interpreted the research as indicating that teacher development of PCK relative to gifted students is particularly dependent upon knowing their students in terms of learning difficulties, conceptions, abilities, interests, etc. It has been reported that good teachers of regular classrooms are frequently not successful teachers of the gifted, because they do not understand the unique characteristics and educational needs of gifted students (Ferrell et al. 1988; Gallagher 2000). In this regard, science teachers of the gifted need to be on familiar terms with the characteristics of gifted students both as individuals and when they are in a group. In other words, teachers need to develop a conception of how individual gifted students function as science learners within the classroom setting. Gaining understanding of general characteristics of the gifted student as categorized within cognitive, affective, physical, intuitive, and societal attributes (Karnes and Bean 2001) is necessary for teachers to make decisions to meet unique needs the students bring into science classrooms. In addition, as a facilitator of science learning, a teacher must engage students in experiences designed to clarify their existing conceptions of the specific topic. From the teacher's perspective, it is important to establish the nature of epistemological thought (Elby and Hammer 2001) regarding the topic that students bring to the session. Only when teachers know the epistemological predisposition of students, can interventions be planned to help students comprehend how the structure of scientific ideas within the instructional session differ from the ideas within the prior knowledge they bring to the classroom. With that knowledge, they can find and implement appropriate approaches for teaching the science topic while accommodating the unique educational requirements. In this regard, the study presented here explored how teachers' perceptions of gifted students impacted the formation of instructional strategies.

McGinnis and Stefanich (2007) concluded their chapter on "Special Needs and Talents in Science Learning" in the *Handbook of Research on Science Education* by writing: "Limited findings suggest that talented science learners do benefit from learning situations that decrease the focus on memorization of information and increase opportunities for problem solving and inquiry" (p. 309). The review of the literature reported here certainly supports this conclusion. It is the hope that this study will add to a relatively sparse literature on the teaching of gifted students as well as be part of the response to the "urgent need" for research regarding talented science learners that McGinnis and Stefanich identified.

Methods

Research Design

This study is a qualitative study with three high school chemistry teachers. At the time of this study, the participating teachers—Amy, Jane, and Lucy (pseudonyms)—were teaching chemistry to identified gifted students within both homogeneously- and heterogeneously-grouped classrooms at the same high school in suburban Atlanta, Georgia. All three teachers are white and female. Their teaching experience ranged from 8 to 21 years. In this study, "gifted" students are those identified and placed in gifted education programs based on criteria established by the Georgia General Assembly and the Georgia State Board of Education. Within the criteria, a student's eligibility to be in gifted education programs is evaluated in four areas at kindergarten age: mental aptitude, achievement, creativity, and motivation. *Homogeneously-grouped classroom* refers to the classroom which consists of only identified gifted students (e.g., Lucy's gifted chemistry), while *heterogeneously-grouped classroom* refers to one which contains both identified gifted students and other students (e.g., Amy's and Jane's honors and college preparatory (CP) chemistry class, and Lucy's advanced placement (AP) chemistry class).

Data Collection

Multiple data sources included classroom observations, semistructured interviews, lesson plans, teachers' written reflections, students' work samples including assessments, and researcher's field notes. We observed three subject matter units for each teacher using a non-participant observation method during one academic year. For each unit, at least three class periods—beginning, middle, and end of the unit—were observed. Each observation was combined with both a pre-observation and post-observation interview. In addition, the teachers were asked to write reflections on their practice. We made short notes at the time of the observations and made expanded notes as soon as possible after each observation. Also, we recorded problems and ideas that arose during each period of observation in a reflection journal.

Data Analysis

The constant comparative method (Charmaz 2000; Glaser and Strauss 1967) was utilized to analyze the data. In the constant comparative method, the data analysis focused on the identification of regularities or patterns in the interviews, observation transcripts, and written reflections in terms of (a) instructional challenges teachers perceive while teaching gifted students, and (b) instructional strategies they employed to meet the challenges. To enhance the trustworthiness of the study we conducted triangulation of multiple data sources, member checking (Patton 2002) and investigator triangulation (Janesick 1994).

Findings

Instructional Challenges Gifted Students Bring into Science Classroom

The data analysis revealed that the teachers encountered a variety of instructional challenges while working with gifted students in their classes. Further the analysis showed that those instructional challenges mostly resulted from the following characteristics of the gifted students: (a) asking challenging questions, (b) being impatient with the pace of others/getting easily bored, (c) having perfectionist traits/having a fear of failure, (d) disliking routine, drills, and busy work, (e) being critical of others, and (f) being aware of being different from others.

Asking challenging questions. Gifted students tended to ask unusual and insightful questions. In some cases, those questions were beyond the scope of the content knowledge the teachers possessed. For example, in Lucy's class, students were asked to design several tests for identifying an unknown compound. When Lucy visited a group of students who decided to use a flame test, she asked a few questions related to science concepts behind the flame test in order to gauge their level of understanding of them. In the middle of the discussion, one student, Stephanie, asked her why the color of the nonmetal anion did not interfere with the visible emission spectrum of a metal cation. Lucy was not able to come up with the answer to the question so she had to say, "That's a great question. I've never thought of it. I should figure that out" (Lucy, Observation #7). How she continued the inquiry based on the student's question is examined later in the manuscript.

As this example implies, the teachers were often challenged and sometimes embarrassed by gifted students' unforeseen questions. An additional aspect of this is shown in Jane's statement below.

> They tend to ask a lot more questions than others. And they'd like to oftentimes do that in front of the rest of the class, which sometimes interrupts other students' learning. They often ask questions [for which] I don't know the answer. They typically want to know why, how. Sometimes it's mentally exhausting (Jane, Interview #2).

This statement implies that both the quantity and the quality of questions from gifted students created challenges for their teachers. It also indicates that this challenge is caused by the gifted students' intellectual curiosity, creativity, and inquisitive attitudes (Clark 1988).

Being impatient with the pace of others/getting easily bored. Gifted students often got easily bored with a regular curriculum, since they were likely to acquire and retain information more quickly than other students (Clark 1988). Consequently, teachers, especially in heterogeneously-grouped classrooms, perceived the act of meeting both gifted students' and other students' educational needs as demanding. Amy put it this way:

> Trying to have a balance between things that will reach them [gifted students], but things that won't frustrate my students who plug away. Trying to plan stuff and do things that will reach both types, which is my biggest challenge (Amy, Interview #2).

This challenge also appeared in homogeneously-grouped gifted classrooms, though it occurred less frequently; "they are different from each other even in the gifted class" (Lucy, Interview #3). Some gifted students also complained when the teachers reviewed the content for other students which they believed they had already learned. In one instance, gifted students who were doing homework were overheard to say "why do I have to hear this again?" (Field note, 2/2/2005). But for these teachers, this was one more way that they recognized the need for strategies to accommodate this gifted students' need.

Having perfectionist traits/having a fear of failure. Perfectionism was often observed in gifted students. This trait was frequently accompanied by stress, anxiety, or self-criticism. Lucy's experience, below, illustrates that characteristic:

> I teach gifted kids, and a lot of them have anxiety attacks and things like that. So I've had every once in a while a parent who will call me and say, "I've tried to tell my child that they don't need to worry about this, but they don't believe me. Can you tell them?" (Lucy, Interview #4).

In addition to perfectionism, fear of failure was often expressed, particularly among gifted underachievers. Their fear of failure caused gifted students to use procrastination or denial as a self-defense mechanism as Amy said:

> Some of the gifted kids want to achieve everything to be perfect. But their coping mechanism is to not care. Because if they cared, their way of caring is just too much stress…they cope by not caring, even though they would probably [do] some of the best work, because they're such perfectionists (Amy, Interview #2).

Disliking routine, drills, and busy work. The teachers routinely confessed their difficulties in coaxing gifted students to do drill-based homework and take notes. Due to their preference for complexity (Karnes and Bean 2001), the students were inclined to resist doing simple work such as repetitive practices or note taking. Jane's statement below portrays this disposition.

> They like a challenge. I've had some gifted students who don't like to do homework because they see homework as more busy work. If it's extra practice, lots of times they don't want to do that (Jane, interview #3).

As implied in this passage, the students had a tendency to differentiate tasks into two sets. "One set contained those educative tasks they considered to be acceptably challenging and was contrasted to the other that fell under the normally fatal label of *busywork*" (Field note, 2/28/2005). Teachers had to search for means to make what they considered to be the important tasks so that the learners would place within the first category.

Being critical of others. Many gifted students are critical of others and themselves (Frasier and Passow 1994). In classroom settings this was often expressed through high expectations for peers. This attribute was enacted as a teaching challenge when grouping students in heterogeneously-grouped classrooms. In addition, teachers were also common recipients of comments related to the gifted students' high expectations. Awareness of these expectations resulted in the teachers being better prepared for their classes' critical dispositions. Jane said:

> Gifted students are like sponges. They absorb everything that I say, but also they have an opinion. They tell me if they think I am wrong. They don't accept any mistakes sometimes. So I have to make sure of everything before I go to class. I have to make sure that I'm really explaining it correctly (Jane, Interview #4).

Evidence for this conclusion arose from both observations and interviews. The teachers were sufficiently skilled in teaching so that "they did not show negative responses to criticism from their students," but it is clear that they felt it and they prepared differently as a result (Field note, 1/20/2005).

Being aware of being different from others. When gifted students are teased by their peers regarding their intellectual abilities, social and emotional stress can result. During classroom observations, it appeared that in order to avoid that stress, some gifted students did not respond to questions or queries in class and minimized their science-related abilities. This point is nicely captured in Lucy's statement:

> I have a kid who said, "I'm a totally different kid when I go to other classes [not gifted classes]. I never talk, because kids always make fun of me. They just look at me like I'm weird." He was like almost the center of every class discussion [in my gifted class]. So a lot of times, these gifted kids feel like big time Xs in a world of Os (Lucy, Interview #2).

In the same interview (and regarding that same student), Lucy said, "I had never really gotten a glimpse into that until that kid was talking about it". This follow-up comment is particularly notable given our knowledge of Lucy as a very student-oriented teacher. If she had little sense of how these students felt in other classes, we suspect that many teachers might not recognize gifted students' emotional issues and neglect the need to deal with those issues while also meeting the challenges of teaching science.

Summary. In this section we have briefly introduced six issues which our research with three chemistry teachers exposed as challenges in the teaching of gifted students. These intersections of the instructional plan with the characteristics of the gifted students pose for teachers an imperative to find complementary responses. For the teacher who does not have knowledge of how gifted students see themselves as different, Lucy's example immediately above is instructive. It seems that her learning was the result of being willing to listen. In the next section, we will turn to the issue of how these teachers created instructional strategies through which they sought to address the unique classroom needs of gifted students.

Instructional Strategies to Meet the Challenges Gifted Students Bring into the Classroom

In response to the challenges previously identified, the teachers strove to apply specially adapted instructional approaches to help gifted students reach their potential. Research with these teachers identified seven adaptations which are presented here under these labels: (a) instructional differentiation, particularly thematic units, (b) variety in instructional modes and students' products, (c) grouping strategies and peer tutoring, (d) individualized support, (e) strategies to manage challenging questions, (f) strategies to deal with perfectionism, and (g) ensuring a psychologically safe classroom environment.

Instructional differentiation: Thematic units. Differentiation refers to strategies used to tailor instruction to create appropriately different learning experiences for individual students (Beecher 1996). The participating teachers implemented a differentiation strategy by using thematic units to "allow individual students including gifted students to work at their pace" (Jane, Interview #5). This change came in the middle of a semester due to the teachers increasing awareness of individual students' differences in understanding basic chemistry concepts. The thematic units were used to teach structure and properties of matter as well as chemical reactions. The units were designed to allow students to engage in intellectually challenging learning activities across the student performance variables in a given class. The intended goal was mastery of core concepts by all of the students.

For example, the teachers created a unit called "Mendeleev Manor," which was a six-week unit to teach chemical reactions through student inquiry. In this unit, students were expected to learn the stoichiometry involved in chemical reactions as well as problem-solving skills. The real-life scenario at the heart of the thematic unit involved a town, Mendeleev Manor, established by Granny DeMole. Granny DeMole had passed on and left her last will and testament challenging each student to determine why her town was mysteriously abandoned in 1988. Further, she wished for them to recover her favorite metals (copper, silver, zinc, and gold) from the town. Students were to use their prior knowledge of chemistry (e.g., properties of matter, types of chemical reactions, and molar relationships of balanced equations) to determine where the metals were in the town. Ultimately the students were to isolate the four metals based on their reactivity. At the outset, the thematic units allowed the teachers to tailor the degree of the open-endedness of questions and the extent of individual guidance. These tools were used to scaffold each student's learning regardless of whether they are gifted or not according to his/her level of understanding. To facilitate students' critical thinking skills and engagement, they also "implemented clever points for students who came up with clever ideas or contributed to an extra special insight or researched ideas" (Field note, 1/21/2005).

As a result, the students could do "whatever they want to do around the thread [central theme], at their pace, in their ways" (Amy, Interview #5) while learning the unit. This feature was emphasized to students by the teachers' recurrent saying: "Guys, this lab has many, many layers. I want you to see how deep you can dig and

how much you can dig" (Jane, Classroom observation #7). As the unit proceeded, it appeared that all students benefited from the differentiated approach. In her written reflection, Lucy identified aspects of the value of this thematic unit recalling students' responses within her gifted chemistry class:

> One struggling student was empowered by the inquiry process of the Mendeleev Manor unit. She said to me, "Even though my lab group made lots of mistakes, in the end, I think our mistakes made me learn more about stoichiometry." Another student was so empowered by the independence she gained in lab that she invented her own techniques and came in after school to try them. When at the Governor's Honors Program (a prestigious six-week summer program), she proposed new techniques for making and investigating uses of Ferro fluids.

Among the three teachers who collaborated to develop the thematic units a consensus emerged; instructional differentiation should be aimed toward the quality of learning not just the quantity of learning. Further, the teachers' consensus encompassed the idea that quality applied to all students' learning including gifted students. Lucy highlighted this point saying:

> Gifted kids are going to take less time doing something than the other kids. So I try to provide more advanced problems or activities, not more of the same thing….A lot of times we're like, "Oh, the gifted kids, they should be able to do more". No, sometimes they need to do less [for a deeper understanding] because they'll turn a molehill into a mountain (Lucy, Interview #2).

This idea of quality was also salient in the teachers' assessment item development. They usually provided extra bonus questions at the end of tests or quizzes to stretch students' potential. These questions were designed to require higher level thinking skills. For instance, one of Jane's bonus questions was about anion replacement. This was a topic the students had not yet learned. Jane, however, believed that their prior learning of cation replacement could enable them to solve the question by transferring their learning from one concept to the other. Her intention with the use of that question was "not to put that as par, as standard, for all students, but to reach a little bit higher and see if some who are capable can apply information and think in a different way to get at the answers" (Jane, Interview #4).

Thus instructional differentiation using thematic units aided the teachers in their attempt to address several of the six challenges they had encountered in teaching gifted students. Foremost, the thematic units allowed the teachers to address the creation of instructional sessions that were challenging and interesting to all students including gifted students and thus addressing the issue of keeping them on task and allaying boredom. The individual nature of the thematic units also aided the gifted students regarding their need to work at their own pace, reduce anxiety, and be able to use their difference from other students to an advantage.

Variety in instructional modes and students' products. As a means to meet individual students' needs, the teachers employed diverse types of instructions such as demonstrations, simulations, laboratories, computer-assistant instruction, discussions, etc. In particular, given the understanding that gifted students prefer

instructional strategies that emphasize independence, the teachers placed particular emphasis on a science fair as an opportunity for gifted students to "jump right into self-selected topics and pull [together] their strengths and thinking" (Amy, Interview #2).

Within the curriculum, the teachers also changed students' products from what had previously been assigned. In other words, they asked students to generate unique products that reflected their own potential. Students' products are defined as "the tangible evidence of student learning" (Maker and Nielson 1996, p. 186). The students' products came in written (e.g., writing essays, science journaling, writing a story, research report, etc.), visual (e.g., Valentine chemistry cards, drawing, etc.), performance (e.g., experiments, simulations, problem solving, science fair, etc.), and oral forms (e.g., PowerPoint presentation, group discussion, arguments, etc.). The major goal of generating unique products was to enable students to use their talents regardless of whether they were more gifted in verbal, mathematical, or scientific thinking.

The teachers' efforts toward creating instructional variation were often facilitated by providing options to their students. In a review section of a test on chemical reactions, for example, Amy offered the following choices during a test review session:

> I'm going to have a seminar now to review this concept. So you can either do that, or I've got a problem you can work in the back of the room. You can move back there and work with a group on that (Amy, Classroom observation #4).

Those options enabled the students to optimize their learning within the limited time while making greatest use of their interests, abilities, needs, and learning styles.

Teaching in the ways shown in this section was addressed to several of the challenges that gifted students present to the instructional plan, but perhaps most significantly, the use of a variety of instructional modes keeps the class from being too routine and predictable. Further, gifted students, as stated earlier, more than others students have a dislike for busywork and repetitious drills.

Grouping strategies and peer tutoring. Another strategy that the teachers employed to meet gifted students' needs in heterogeneously-grouped classrooms was to use both homogeneous grouping and peer tutoring. They believed that similar-ability grouping provided peer stimulation and emotional support. Amy said:

> I sometimes put my students who are gifted together because they understand each other, listen to each other, so their ideas can flow, and therefore can go on a tangent. They need people who understand them. So I think sometimes putting them together is helpful (Amy, Interview #2).

Peer tutoring was frequently used for gifted students to develop social skills and learn from others. Jane, in her particular approach, ran peer-tutoring sessions every Thursday after school for the students who needed extra help. During these sessions, Jane recognized that involvement in peer tutoring helped her gifted students to be

patient with individuals who did not learn in the same way or at the same pace they did. She found that these tutors came to understand their peers better. In her reflection, she wrote about one of her gifted students who participated in peer tutoring:

> Ben is exceptionally bright, tends to ask thoughtful questions, and displays critical thinking in class. Ben has been identified as gifted, but he emitted a poor self-image due to high expectations of himself. He works very well with students and is very patient and deliberate in his explanations. The students tutored by Ben have shown great gains in their performances in class. Ben seems to get more confident in himself (Jane, Written reflection).

This description implies that peer tutoring is likely to allow gifted students to continue their own educational progress, understand the needs of others, and develop skills for working with others. Through this activity, the teachers have found ways to respond to, or at least create individual student recognition of, three of the six challenges that gifted students present. These include (a) being patient with the pace of others, (b) being critical of others, and (c) being aware of being different from others.

Individualized support. Teachers' instructional assistance for individual students served as a means to stimulate and satisfy gifted' students' intellectual curiosity. The teachers gave individual attention and support whenever needed. This individualized support was often initiated by the teachers though it commonly originated with the student as well. For instance, when Lucy sensed that a student had difficulty in learning a particular topic, she called the student after school and said, "You look like you were struggling with this in class. Can I help you?" (Lucy, Interview #6). Jane encouraged students to come by after school and thus "her classroom was always full before and after school" (Field note, 2/14/2005). Amy usually provided detailed comments on students' lab reports or essays.

Through exchanges with individual students, the teachers came to better understand each student's learning difficulties, understanding levels, and reasoning styles. Those understandings enabled the teachers to scaffold individual students' learning and modify their instructional repertoires. Considering the time constraints and the demands for fully covering curricula, taking extra time outside of class periods for individual support was an effective way for the teachers to demonstrate a commitment to individual students' learning and further develop their knowledge for teaching.

Strategies to manage challenging questions. When the teachers faced challenging questions from students, they tended to use the questions as a learning opportunity for both students and themselves. Students' questions served as a stimulus for the teachers to broaden and deepen their subject matter knowledge. As described earlier (see "asking challenging questions" section), in the middle of Lucy's inquiry lab on chemical compounds, a student, who was doing a flame test asked Lucy why the color of the nonmetal anion did not interfere with the visible emission spectra of a metal cation. The teacher had never thought of this aspect of the laboratory, so she researched the question that night and was able to develop questions focused on the student's query for a follow-up activity the next day. These questions were used to

enhance students' inquiry about energy levels, wave lengths, and the creation of visible spectra, but produced a secondary result when Lucy realized that her subject matter content knowledge and teaching strategies related to that topic was also deepened.

In addition, the teachers oftentimes used students' questions to initiate other students' thinking skills. Jane elaborated this strategy:

> When those moments arise where gifted students ask challenging questions, I try to pull in what they already know and ask them further questions. Instead of letting me just tell you what it is, I want them to work at finding answers together. And that process is more than just finding the answer. The most important part is that they think about it and they model that for other students. Other students learn from them (Jane, Interview #2).

Thus, the teachers made use of the student's challenging questions not only as a tool for pushing the students to re-examine what they already have learned, but as a positive force to enhance their own knowledge of the topic and other aspects of the instructional session.

Strategies to deal with the perfectionism. In order to help gifted students manage their perfectionist traits, the teachers encouraged them to set realistic goals. This strategy was significantly featured in Lucy's gifted class. When her students were working on science fair projects, she helped them to make realistic plans, taking into consideration their attitudes. She said:

> If between September and November 16th you haven't been able to set up your project, you have to think what [would] make you able to do that in the next couple of days, okay? My major point is not to be unrealistic about your plan. You know, that's just not going to work (Lucy, Class observation #3).

In addition to setting realistic goals, the teachers helped students develop self-acceptance and recognition of their limitations. Amy's statement below exemplifies those strategies:

> I deal with perfectionism a lot and we talk about the trade off. "You can do perfect on this, but you cannot get all this stuff done, because you don't have time for all the other stuff. You are not getting sleep. You're getting stressed out." And we go back and forth, just making them aware of their own perfectionism. Sometimes I ask them to write down their strengths and weaknesses. That helps a lot (Amy, Interview #2).

The approaches used by the teachers to help the students deal with perfectionism were aimed at getting the students to accept limitations of what they could realistically accomplish, so that they could put their perfectionism in an appropriate compartment of their lives. But the teachers also hoped that the students would come to appreciate that their fear of failure, which typically accompanied the feelings of perfectionism, was also not based in rational assessment of their potential.

Psychologically safe classroom environments. Among the most personal concerns the teachers had to face in teaching gifted students were the emotional

issues caused by their students' feeling of "being different." Those issues were frequently discussed openly between the teachers and gifted students. In the Lucy's gifted class, for example, she noticed that a student was acting sullen due to his peers' teasing about his inexplicable intellectual curiosity in their social studies class. Then she initiated discussion about being gifted in this way:

> You guys are the gifted kids, okay? You guys have a lot of opportunities that some other students don't, okay? But the saddest thing is when you guys all of the sudden have doors closed because of poor grades, because you were bored or you were feeling isolated, or whatever. I understand there's a blessing and a curse for being gifted (Lucy, Class observation #5).

The students, then, started expressing their difficulties, experiences, and emotions. This might not have naturally occurred if Lucy had not striven to maintain a classroom atmosphere in which every student felt that everything was accepted, understood, and valued. Lucy elaborated this point as follows:

> I think with the gifted kid, there's a lot of gray [area]. They sometimes talk of how hard it is for them to get started because they're like, "My mind is swimming with all these ideas. How do I focus them?" They know I understand what being gifted means to them, so they do feel safe to express their emotion in my class. I've tried to build that kind of environment and rapport with them over time (Lucy, Interview #9).

Lucy's statement offers evidence that it is the teacher who sets the environment which encourages or destroys interests, develops or neglects abilities, fosters or suppresses creativity, and facilitates or aggravates achievement.

Summary. In the previous sections, we have examined how three chemistry teachers attempted to make a connection between challenges they faced in teaching gifted students and the instruction-related responses they enacted. We recognize that there is an inherent question about the credibility of our approach. In one action, we have described both our process for identifying the challenges associated with teaching gifted children while also describing the ways the teachers dealt with the issues raised. The credibility issue, it seems to us, resides primarily in the belief that if the responses the teachers make are at all successful, then there will be little for the classroom observation to show as to what the root dilemmas were. However, teaching is an ongoing act of shifting practice and thinking to deal with new issues encountered in the classroom. These teachers are well experienced and gave much of the information about challenges by retrospectively examining issues they had faced earlier in their careers. But this research also adds credence to the idea that expertise in teaching is very specific to both individual students and fine-grained topics. These teachers recognized, as we did, that there will not be a permanent resolution to the challenges of teaching, whether we are discussing gifted students or not. A steady progress as measured externally by available indicators of success and internally by on-going reflection on practice is perhaps the best hope for the future.

Discussion and Implications

The data analysis indicated that teachers encountered a variety of instructional challenges while they were dealing with gifted students within both homogeneously and heterogeneously grouped classrooms. Those challenges were often caused by the gifted students' unique characteristics and which led the teachers to modify their instruction to respond appropriately. One challenge was that gifted students asked frequent and, often, embarrassing questions due to their intellectual curiosity. Gifted students' ability to learn more quickly sometimes caused them to be bored with the pace of the regular curriculum and to lose interest in learning. Their perfectionism and negative attitudes toward routine and busy work oftentimes challenged the teachers. Furthermore, many gifted students were critical of other students and expressed high expectations toward others as well as toward themselves. As a result, teachers used these characteristics within their instruction as a reason for strategic decisions such as those related to grouping students. It was the perception of these teachers that gifted students frequently suffered from emotional issues that resulted from their awareness of being different. Further, it was the teachers' perception that those emotional issues sometimes resulted from gifted students' academic decisions which too often manifested as underachievement in school. In our study, teachers also felt that they were required to help gifted students cope with the emotional issues more commonly than with other students. All of these factors combined to make the case that these teachers had an increased instructional load due to teaching of gifted students.

As a result of their recognition of gifted students' special educational needs, the teachers created a variety of instructional strategies. As the teachers became more aware of gifted students' cognitive and affective characteristics, they came to be more willing to develop and implement diverse instructional challenges to be responsive to the students' particular needs, abilities, and attitudes. Instructional differentiation was a strategy that the teachers commonly employed to provide appropriately challenging tasks to all students including gifted students. In order to provide qualitatively differentiated learning opportunities to all students, they created thematic units that allowed more flexibility for tailoring instruction to individual students' levels of understanding as compared to teaching chapter by chapter in textbooks. Although the effects of peer tutoring on gifted students are controversial (Robinson 1997), this study showed that peer tutoring was beneficial to all the students including the gifted students.

This study provides evidence that teachers' understanding of students impacts their instructional strategies and furthers the development of knowledge for teaching. This implies that teachers understanding of their students' cognitive and affective dispositions serve as one prerequisite for valid pedagogical adjustments intended to facilitate student learning. In this regard, both pre and inservice teacher education programs should provide opportunities for teachers to research or analyze their students in terms of reasoning types, learning styles, motivation, characteristics, and interests (e.g., Geddis 1993; Lederman et al. 1994; Van Driel et al. 1998).

This study revealed that the teachers tailored their instruction to meet gifted students' educational needs and advance the students' science learning. The

instructional strategies the teachers implemented were not content-free skills or strategies. Rather, they applied specially adapted pedagogical procedures for the specific learning objectives through integration of subject matter knowledge and pedagogical knowledge. This finding suggests that courses that are used to fulfil the requirements for certifications to teach gifted students should focus on how to transform subject matter knowledge, and how to relate the transformation to gifted students instead of teaching simply a set of general teaching methods that can be applied to any content area for teaching gifted students.

In a review on the competencies of successful teachers of gifted learners, Feldhusen (1997) cautioned that the competencies needed for teaching certain specific content domains, such as science and mathematics, could be different from those needed for teaching other domains such as art and music. This finding builds on a previous statement by Lindsey (1980) that teachers of the gifted need specific pedagogical competencies related to the specific type of giftedness. Therefore, education of the teachers who are working with gifted students needs to be more content-specific rather than just focus on general characteristics of gifted students and content-free instructional strategies.

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